A STUDY OF MORPHOLOGY, PROVENANCE, AND MOVEMENT OF DESERT SAND SEAS IN AFRICA, ASIA, AND AUSTRALIA

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Type I Progress Report
ERTS-A

A STUDY OF MORPHOLOGY, PROVENANCE, AND MOVEMENT OF DESERT SAND SEAS IN AFRICA, ASIA, AND AUSTRALIA

By Edwin D. McKee and Carol S. Breed

ABSTRACT

Planned analysis of eolian sand distribution and depositional environment is underway, although color mosaics are only about half completed and cannot be finished until additional orders for color prints have been filled.

Quantitative analysis of sand sea patterns based on ERTS-1 imagery continues, using a visual method of dune density measurement. At present dune density measurements have been completed for Australia and Namaland (South West Africa) and are partially finished for Saudi Arabia and North Africa. In addition to the visual method already underway, a method involving custom processing of ERTS-1 computer-compatible tapes is currently being investigated.

Meanwhile, data concerning the controlling factors, especially meteorological, of dune patterns are being gathered, and overlays indicating the direction, velocity and constancy of sand-moving winds are being prepared. An overlay for the South West Africa dune site has been completed and those for Yuma-Sonora and White Sands are nearly finished. Overlays for Pakistan and the Australian sites are started.

Requests for supplemental imagery for China, U.S.S.R., and North Africa from Skylab 3, in the form of handheld photography, have been made. A report on the geometry and growth of the White Sands, New Mexico, dune field covering significant ground truth recently obtained from that site has been completed and is awaiting publication.

As progress continues on the analysis and recording of sand body patterns and their internal structures, the application of these data to an understanding of ancient eolian sandstones with respect to exploration for water, oil, gas and other fluids that migrate through these bodies becomes increasingly apparent.

Type I Progress Report
ERTS-A

a. Title: A Study of Morphology, Provenance, and Movement of Desert Sand Seas in Africa, Asia, and Australia

ERTS-A Proposal No.: SR-131

b. GSFC ID No. of P.I.: IN-402

c. Problems relating to progress:

The project now has sufficient imagery in hand and on order that planned analyses of eolian sand distribution and depositional environment are in progress. Phase III can be successfully completed when all of our orders have been filled. At present, however, only 22.5 percent of our orders for color prints have been filled, and our color mosaics of the foreign test sites are only about half completed. We have devised means of temporarily continuing work without the remaining color imagery, but unless the project can be extended beyond the end of the calendar year, we may run out of time and funds for analysis before the necessary color imagery has arrived. Most important, the significant findings of this project, which have a potential usefulness for the geological exploration for oil or water, will be seriously curtailed by the requirement that we make a final report based on incomplete imagery and by the lack of adequate time to develop the supporting ground truth data needed to substantiate the conclusions reached. We are therefore requesting an extension of our contract to 31 March, 1974, to provide the necessary time for our orders to be filled and our final report to be prepared.

d. Discussion and plans:

Quantitative analysis of the sand sea patterns seen on ERTS-1 imagery has begun, utilizing a number of techniques, as follows:

1. We are investigating the usefulness of custom processing of ERTS-1 computer-compatible tapes, through the efforts of Larry Soderbloom and George Ulrich of the U.S. Geological Survey Center for Astrogeology, Flagstaff. This investigation has two parts:

a. Parts of ERTS-1 imagery that include small fields of very bright sand dunes are being enlarged and contrast-enhanced to see if these techniques will provide higher spatial and radiometric resolution of these areas than do the bulk-processed images. Strips of computer-compatible tapes (bands 4 and 7) of E1153-17103 (White Sands, New Mexico) were "stretched" by this method and enlarged prints were made that do indeed show greater detail at a more useful scale than do the bulk-processed black-and-white prints of the same image. The same method will be tested on imagery of two other small dunefields, the Algodones dunefield in California and the Gran Desierto dunes of Sonora, Mexico (E1159-17445 and E1159-17451, respectively).

b. Computer processing to provide density frequency analyses of imagery in areas of relatively simple and consistent dune patterns is planned as soon as the necessary tapes arrive.

2. Photo-linear analysis of dune patterns by laser optical diffraction is being investigated through cooperation with L. K. Lepley of the Office of Arid Lands Studies, University of Arizona, Tucson. Dr. Lepley has not yet reported the results of this experiment.

3. A visual method of measuring dune densities has been developed by Dana Gebel of this project, and analyses have been completed for the Simpson Desert of Australia and the Namaland dunes of South West Africa. Dune density analyses for parts of Saudi Arabia and North Africa are in progress. The method used by Mr. Gebel is to count (twice) the dune ridges that cross a 50-km line measured normal to the trend of the dunes, and to express the average of the two counts as dunes per kilometer for that sample.

Several sample counts are made for each geographic area, and the resulting figures are plotted on a histogram that shows the frequency of distribution of classes of dune density in that region. Figure 1 is a

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Figure 1.--Near Here.

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composite of parts of ERTS-1 images (band 7) that illustrates typical linear dune patterns in North Africa (test site 1), Saudi Arabia (test site 15), the Simpson Desert (test site 13) and South Africa (test site 4). Superimposed on the image from each site is a histogram showing the frequency of distribution of dune densities in that image.

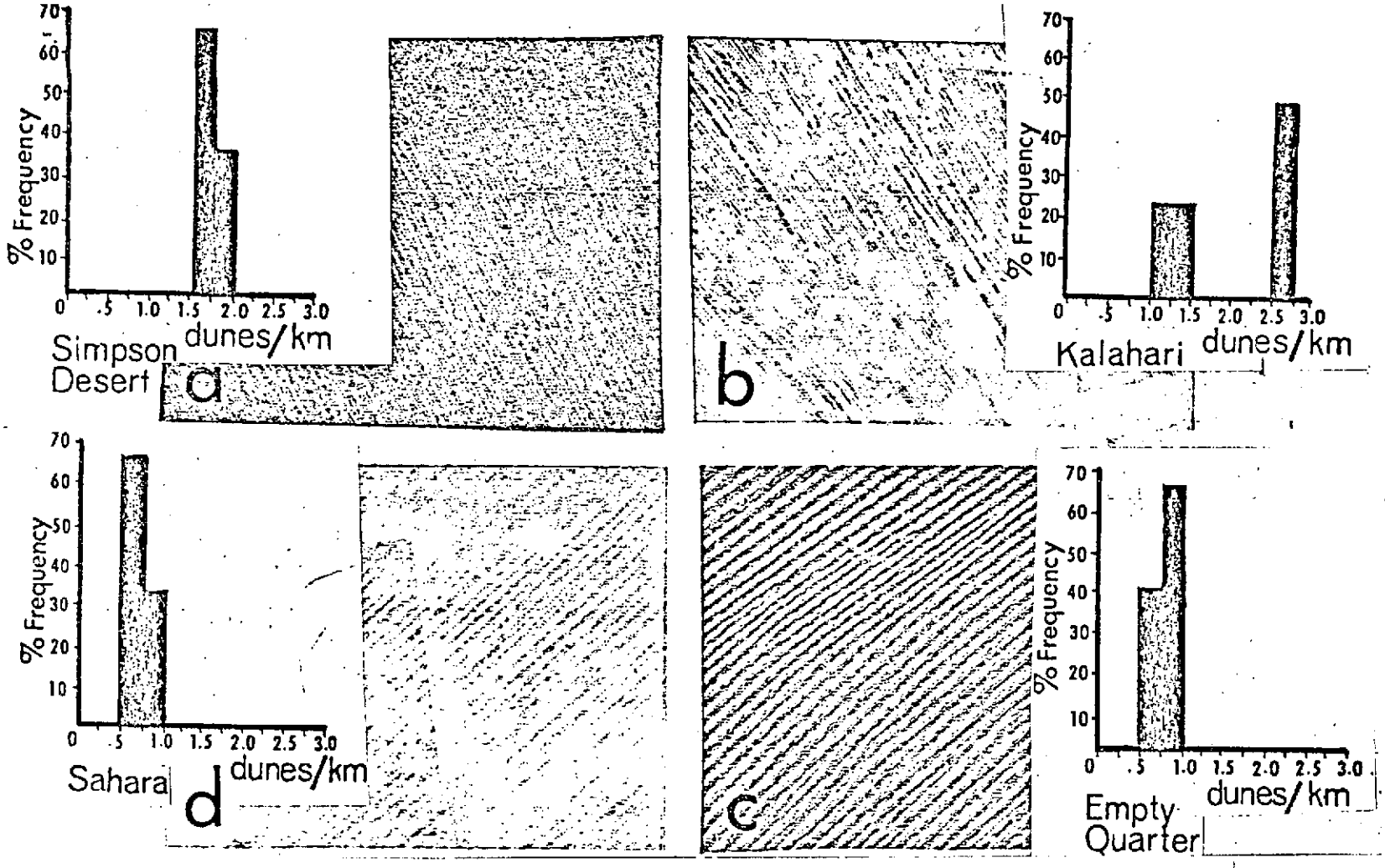

Figure 1. Portions of ERTS-1 images showing linear (parallel straight) dune type occurrence in four widely separated sand seas: a) Australia; b) Southwest Africa; c) Saudi Arabia; d) North Africa. The systematic spacings of the dunes are measurable and comparable, as indicated by the histograms.

This sample illustration shows the capability provided by ERTS-1 imagery for measuring and comparing dunefield characteristics in deserts having similar patterns of development despite wide geographic separation; this capability did not exist before ERTS-1, which provides for the first time, samples (images) of a constant and uniform size (scale), from remote and inaccessible sand seas all over the world.

The plan is to use such visual methods, with whatever more sophisticated methods prove feasible and not too expensive, to relate dune density and other measurable features of sand seas to controlling factors such as wind regime, depth of the sand cover, distance from sand source, presence or absence of barriers, moisture, vegetation, and time. Such analyses will provide regional pictures (thematic maps) of the environment of deposition of eolian sand in the major deserts of the world.

4. Mr. Steven Fryberger of this project is gathering information about the controlling factors outlined above from meteorological data, geological reports, aerial photos, maps of all kinds and quality, and other supporting ground truth sources. He has now received and plotted sufficient wind data for the South West African test sites that this overlay is nearly complete. However, the color mosaic on which to mount the mosaic is not complete.

Meteorological overlays showing the direction, speed, and percentage frequency of sand-moving winds are nearing completion for the Yuma-Sonora dunefields and for White Sands; they have been started for Australia and the Pakistan desert, and overlays for other deserts will be prepared as soon as the necessary ground truth data are acquired. Student volunteers on this project--Marion Blancett, Kathy Nation, Chuck Waldron, Philip Gall, and Gary Dean--have greatly helped with the preparation of mosaics and the tabulation of data.

5. Linear density transparencies, which were ordered 9 August, 1973 for analysis of dunefields that are extremely reflective, such as White Sands, New Mexico, and parts of Arabia and North Africa, have not yet arrived.

6. Skylab proposal: We have requested supplemental satellite imagery to be acquired through handheld photography, by Skylab 3 astronauts, of selected areas (China, North Africa, etc.) for which little aerial photography is available.

e. Results and application:

The regional studies of sand seas made possible by analysis of ERTS-1 imagery have established that widespread patterns of eolian sand deposition exist in many places and that similarities and differences in these patterns can be measured and compared, on a worldwide scale. Analysis of the relationships of depositional patterns to controlling factors will require completion of the color mosaics of the test sites, and acquisition of adequate supporting ground truth data, especially wind data.

Once analyses are complete, the results will be applicable to the regional study of ancient eolian sandstones. Such sandstones were formed many millions of years ago under conditions believed to be identical to those under which the sand seas that we are observing form today. The understanding of the deposition of eolian sands provided by analysis of ERTS-1 imagery will be applicable to an understanding of the structure and distribution of ancient eolian sandstones and their potential as reservoirs of oil and of water.

f. Reports:

A paper entitled "Geometry and Growth of the White Sands, New Mexico, Dune Field" by Edwin D. McKee and Richard J. Moiola has been prepared for publication in the Journal of Research of the U.S. Geological Survey. This report discusses significant ground truth obtained at White Sands through studies of dune trenching and core drilling; it interprets features of structure heretofore not clearly understood but closely related to certain sand patterns illustrated in ERTS images for that area.

g. Changes in operation:

Personnel: Mr. Steven Fryberger was added to the project staff October 9, 1973, as assistant in charge of meteorological data.

h. Changes in standing order forms: None

i. ERTS Image Descriptor forms: Attached

j. Data Request Forms: Attached.

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS* Dunes			DESCRIPTORS
E1217-06090	X			
E1235-06091	X			
E1219-06210	X			
E1239-06314	X			
E1240-06142	X			
E1293-06315	X			
E1293-06313	X			
E1313-06443	X			grooves

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	DUNES			
E1010-17172				clouds
E1177-17452				peninsula
E1322-17510				clouds
E1304-17511				peninsula
E1304-17504				city
E1320-17395				sea
E1320-17393	✓			
E1321-17445	✓			
E1321-17451	✓			
E1321-17454				clouds, peninsula
E1315-17103	✓			
E1318-17271				volcano
E1318-17265				valleys, Plateau
E1337-17372				city
E1337-17314				valleys, rivers, lake
E1337-17320				mountain, valleys, lake
E1213-10555	✓			
E1228-10375	✓			mountains
E1283-10445	✓			
E1229-10443	✓			in valleys

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	Dunes			
E1241-04552	x			
E1241-04545	x			
E1308-04253	x			lakes
E1308-04255	x			
E1308-04262	x			mts, rivers,
E1234-04144				mts, pediplains
E1279-05062	x			
E1296-05005	x			
E1296-05002	x			
E1296-05000				glaciers, mountains
E1328-04364	x			
E1328-04374	x			
E1328-04373	x			Wadis (Arroyos)
E1322-04024	x			
E1326-04254	x			
E1307-04194	x			
E1307-04201	x			
E1314-05004	x			
E1314-05001	x			
E1243-03222	x			
E1243-03224	x			
E1241-03114	x			
E1244-03283	x			
E1244-03280	x			
E1243-05103	x			
E1243-05101	x			
E1243-05094	x			
E1228-05272	x			

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS* Dunes			DESCRIPTORS
E1227-08503	X			
E1227-08501	X			
E1246-08565	X			
E1246-08560	X			
E1246-08553	X			
E1320-09045	X			
E1318-08550	X			
E1318-08544	X			
E1318-08541	X			
E1321-09103	X			
E1321-09110	X			
E1222-08331	X			
E1308-08111	X			
E1208-08104	X			
E1308-08102	X			
E1235-04200	X			
E1239-04424				cuesta, floodplain
E1239-04433	X			clouds
E1239-04435	X			
E1239-04442				Mountains, snow
E1238-04372	X			

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Dunes			
E1229-10445	X			
E1229-10440	X			dome
E1239-10434	X			
E1227-10335	X			
E1263-10335	X			
E1262-10281	X			
E1279-10222	X			
E1279-10224	X			
E1280-10283	X			
E1280-10280	X			
E1247-10434	X			
E1301-10435	X			
E1201-10441	X			
E1301-10432	X			(contrail visible)
E1302-10493	X			
E1302-10500	X			
E1209-08505	X			
E1209-08500	X			
E1209-08503	X			
E1228-08553	X			
E1231-09140	X			
E1229-09020	X			
E1229-09014	X			

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	Dunes			
E1209-07041	X			
E1209-07044	X			
E1286-07330	X			
E1286-07323	X			
E1247-07160	X			
E1211-07161				dendritic drainage
E1211-07154	X			
E1211-07152	X			
E1285-07265	X			
E1244-06593	X			
E1244-06591	X			
E1300-07095	X			
E1320-07204	X			
E1320-07211	X			
E1314-06421	X			
E1304-07322	X			
E1304-07325	X			
E1236-06143	X			
E1236-06140	X			
E1239-06330	X			
E1239-06323	X			
E1163-06083	X			
E1217-06090	X			

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Dunes			
E1227-00264	X			
E1227-00273	X			
E1221-23574				dendritic drainage
E1221-23585	X			
E1296-00090	X			
E1296-00092	X			
E1316-00195	X			
E1315-00140	X			
E1315-00143	X			
E1315-00145	X			
E1313-00033	X			
E1245-00274	X			
E1245-00271	X			
E1245-00265	X			
E1230-07214	X			
E1231-07272	X			
E1231-07270	X			
E1231-07263	X			
E1226-06590	X			
E1208-06583	X			
E1208-06585	X			
E1226-06584	X			

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E1230-00442	X			
E1230-00440	X			
E1248-00434	X			
E1247-00382	X			
E1247-00375	X			cuestas
E1321-00500	X			
E1321-00491	X			
E1207-00151	X			
E1207-00153	X			lakes
E1210-00331	X			sinks ?
E1210-00315				river, cuestas
E1210-00324	X			sinks ?
E1210-00322	X			
E1223-00035	X			
E1224-00100	X			rivers lakes
E1224-00093	X			
E1224-00091	X			
E1227-00262	X			cuestas
E1227-00271	X			

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	Dunes			
E1219-06133	X			
E1322-05453	X			
E1322-05451	X			
E1288-05570	X			
E1288-05575	X			
E1288-05582	X			
E1286-05460	X			
E1286-05453	X			
E1309-06152	X			
E1233-01002	X			
E1233-01000	X			
E1233-00593				lake, playa
E1323-00593	X			
E1323-00590	X			lake
E1322-00543	X			
E1322-00550				
E1213-00435	X			
E1213-00500	X			
E1213-00493	X			
E1214-00554	X			
E1214-00552	X			

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	Dunes			
E1221-06264	X			sediments lakes
E1218-06090	X			
E1218-06083	X			lakes, rivers,
E1218-06081	X			
E1236-06090	X			
E1236-06084	X			
E1235-06035	X			
E1235-06032	X			
E1235-06025	X			
E1235-06023	X			
E1235-06020	X			
E1220-06205				lakes
E1220-06203	X			
E1220-06200	X			
E1217-06034	X			
E1217-06031	X			
E1217-06025	X			
E1217-06022	X			
E1217-06020	X			
E1234-05583	X			
E1219-06142	X			river
E1219-06135	X			

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PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS* Dunes			DESCRIPTORS
E1281-05213	X			
E1281-05204	X			
E1281-05215	X			
E1280-05145	X			
E1280-05152	X			
E1280-05154	X			
E1280-05161	X			
E1282-05265	X			
E1282-05271	X			
E1282-05274	X			
E1279-05091	X			
E1298-05154	X			
E1298-05145	X			
E1297-05093	X			
E1297-05090	X			
E1299-05203	X			
E1299-05205	X			
E1299-05212	X			
E1299-05214	X			
E1300-05220	X			
E1300-05264	X			
E1318-05263	X			
E1318-05265	X			
E1218-06092	X			

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E1209-05212	X			
E1209-05210	X			
E1209-05203	X			
E1209-05215	X			
E1226-05150	X			
E1228-05265	X			Meandering river
E1227-05220	X			
E1227-05213	X			
E1227-05211	X			
E1227-05204	X			River
E1208-05160	X			
E1208-05154	X			
E1208-05151	X			
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*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO NDPF USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

GSFC 37-2 (7/72)

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